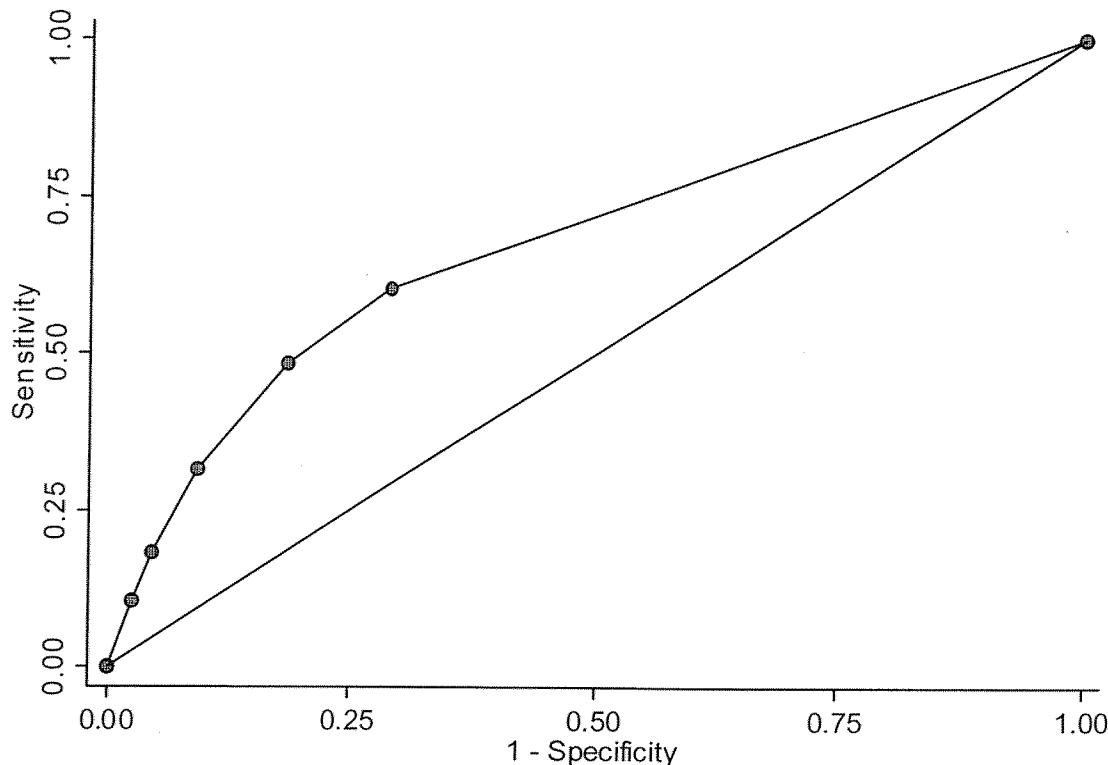


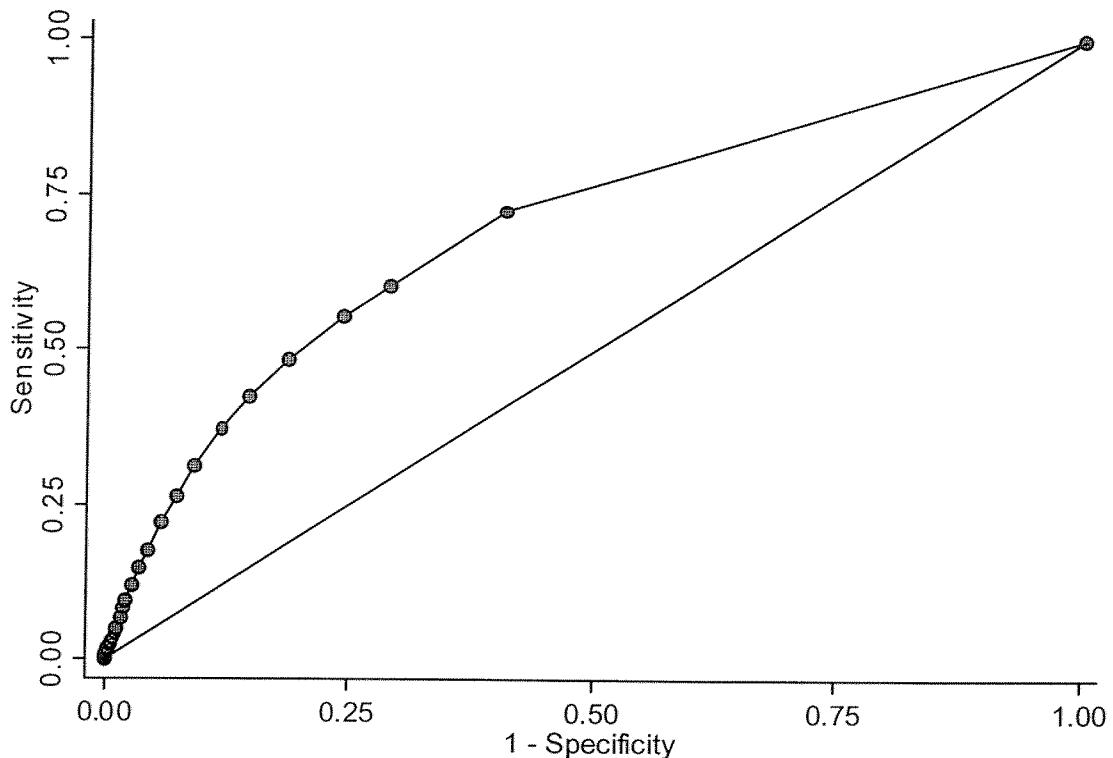
Exhibit 6  
**Criminal History Category:**  
**ROC Curve for Two Year Primary Recidivism Definition**  
Recidivism Study 2003



ROC Area = 0.6786  
Standard Error = 0.0041  
95% Confidence Interval = 0.67064 to 0.68657

SOURCE: U.S. Sentencing Commission, FY1992 Recidivism Sample (U.S. Citizens), 2003, weighted data.

**Exhibit 7**  
**Criminal History Points:**  
**ROC Curve for Two Year Primary Recidivism Definition**  
Recidivism Study 2003



ROC Area = 0.6992  
Standard Error = 0.0041  
95% Confidence Interval = 0.69113 to 0.70721

SOURCE: U.S. Sentencing Commission, FY1992 Recidivism Sample (U.S. Citizens), 2003, weighted data.

Exhibit 8

**Summary of Predictive Power of Current Criminal Measures:**

**Criminal History Category and Criminal History Points**

Two Year Statistics Using Different Recidivism Definitions  
Recidivism Study 2003

<b>Instrument and Recidivism Definition</b>	<b>Area Under Curve (AUC)</b>	<b>95% Confidence Interval</b>	<b>Standard Error</b>
<b>Primary Recidivism Definition</b>			
Criminal History <i>Category</i> Measure	0.6786*	(0.6706, 0.6866)	0.0041
Criminal History <i>Points</i> Measure	0.6992*	(0.6911, 0.7072)	0.0041
<b>Re-Conviction Recidivism Definition</b>			
Criminal History <i>Category</i> Measure	0.6396*	(0.6256, 0.6537)	0.0072
Criminal History <i>Points</i> Measure	0.6510*	(0.6366, 0.6654)	0.0073

\*Significantly different from 0.5 at p<0.05.

SOURCE: U.S. Sentencing Commission, FY1992 Recidivism Sample (U.S. Citizens), 2003, weighted data.

**Exhibit 9**  
**Primary Definition Recidivism Rates<sup>1</sup> for General Demographic Variables, by Criminal History Category**  
**Gender, Age at Sentencing, and Race**  
 Recidivism Study 2003

**CRIMINAL HISTORY CATEGORIES**

	<b>Total</b>		<b>Category I</b>	<b>Category II</b>	<b>Category III</b>	<b>Category IV</b>	<b>Category V</b>	<b>Category VI</b>
	Percent	Recidivating	Percent	Percent	Percent	Percent	Percent	Percent
<b>Demographic Characteristics</b>								
<b>TOTAL<sup>2</sup></b>	<b>24,335</b>	<b>15,429</b>		<b>2,857</b>	<b>2,844</b>	<b>1,359</b>	<b>779</b>	<b>1,067</b>
<b>Gender</b>								
Female	13.7	10.0	23.6	30.7	40.0	36.8	39.0	
Male	24.3	15.2	24.1	34.7	45.0	52.8	56.3	
<b>Age at Sentence</b>								
Under 21	35.5	29.5	35.6	54.7	64.3	60.1	55.0	
21 – 25	31.9	22.3	29.1	42.7	55.1	70.1	68.1	
26 – 30	23.7	13.3	27.3	33.6	43.9	53.1	58.8	
31 – 35	23.8	14.6	22.7	32.7	42.7	50.8	59.3	
36 to 40	19.7	12.1	23.2	29.4	33.1	40.0	51.3	
41 to 50	12.7	6.9	13.3	24.5	45.3	35.7	41.3	
Over 50	9.5	6.2	13.9	19.8	21.0	57.1	41.1	
<b>Race</b>								
White	16.0	8.9	18.9	27.8	42.8	46.8	50.9	
Hispanic	24.3	18.9	22.9	36.0	28.1	47.0	57.8	
Black	32.8	23.7	31.4	41.6	48.0	55.6	60.7	
Other <sup>3</sup>	26.4	15.5	35.9	58.3	39.6	100.0†	57.1	

<sup>1</sup> Primary recidivism definition based on offender's re-arrest, including supervised release/probation violations, re-arrest, or re-conviction.

<sup>2</sup> Number of offenders with a 24 month period at risk of recidivating following either initiation of probation (for offenders receiving probation-only sentences) or release from confinement (for those offenders receiving confinement sentences).

<sup>3</sup> "Other" race category includes Native Americans and Asians.

† Indicates fewer than 10 sample subjects. Findings may not be statistically significant.  
 SOURCE: U.S. Sentencing Commission, FY1992 Recidivism Sample (U.S. Citizens), 2003, weighted data.

**Exhibit 10**  
**Primary Definition Recidivism Rates<sup>1</sup> for General Demographic Variables, by Criminal History Category**  
**Employment, Education, Marital Status, and Illicit Drug Use**  
 Recidivism Study 2003

CRIMINAL HISTORY CATEGORIES						
Demographic Characteristics	Total	Category I Percent	Category II Percent	Category III Percent	Category IV Percent	Category V Percent
	Recidivating	Recidivating	Recidivating	Recidivating	Recidivating	Recidivating
<b>TOTAL<sup>2</sup></b>						
Employment Status <sup>3</sup>						
Unemployed	32.4	20.6	26.8	39.4	48.0	53.0
Employed	19.6	12.7	23.3	32.1	43.1	50.8
Educational Attainment <sup>4</sup>						
Less Than High School	31.4	21.3	31.3	38.5	49.8	50.9
High School	19.3	10.6	21.8	32.5	40.1	53.5
Some College	18.0	13.9	17.8	29.0	39.0	45.6
College Graduate	8.8	7.1	6.5	18.5	34.6	73.3
Marital Status						
Never Married	32.3	22.7	32.3	44.6	46.9	56.8
Legal Marriage	13.8	9.8	13.9	25.1	40.0	41.3
Divorced	19.5	9.8	23.3	27.2	44.0	40.1
Other <sup>5</sup>	22.9	12.9	23.1	31.4	45.1	62.0
Illicit Drug Use <sup>6</sup>						
No Illicit Drug Use	17.4	10.8	21.2	31.5	40.2	53.5
Illicit Drug Use	31.0	21.9	27.5	37.6	49.6	49.8

<sup>1</sup> Primary recidivism definition based on offender's re-arrest, including supervised release/ probation violations, re-arrest, or re-conviction.

<sup>2</sup> Number of offenders with a 24 month period at risk of reconviction following either initiation of probation (for offenders receiving probation-only sentences) or release from confinement (for those offenders receiving confinement sentences).

<sup>3</sup> Employment status during the year prior to the instant offense. "Employed" includes alternative forms of employment and "Unemployed" includes missing values.

<sup>4</sup> Educational Attainment at the time of the instant offense.

<sup>5</sup> "Other" marital status category includes "Co-habiting," "Widowed," and "Separated."

<sup>6</sup> Illicit drug use during the year prior to the instant offense. Missing values counted as "No" illicit drug use.

<sup>\*</sup> Indicates fewer than 10 sample subjects. Findings may not be statistically significant.

**Exhibit 11**  
**Primary Definition Recidivism Rates<sup>1</sup> for Instant Offense Characteristics, by Criminal History Category**  
**Instant Offense Level and Primary Sentencing Guidelines**  
 Recidivism Study 2003

<b>CRIMINAL HISTORY CATEGORIES</b>						
<b>Offense Characteristics</b>	<b>Total</b>		<b>Category I</b>		<b>Category VI</b>	
	Percent	Recidivating	Percent	Recidivating	Percent	Recidivating
<b>TOTAL<sup>2</sup></b>	<b>24,335</b>	<b>15,429</b>		<b>2,857</b>		<b>1,359</b>
<b>Instant Offense Level</b>						
01 – 08	22.5	15.1	29.8	37.6	44.1	54.6
09 – 10	22.5	9.6	18.3	45.4	51.0	54.4
11 – 12	21.7	8.7	38.0	39.1	50.8	52.2
13 – 16	22.2	14.8	23.5	37.4	39.5	50.8
17 – 21	27.3	17.5	25.7	37.5	44.1	58.1
22 – 25	22.8	13.3	22.5	33.3	40.3	59.6
26 – 30	20.7	18.9	19.7	19.2	39.5	61.6
31 – 43	17.5	11.1	12.2	22.4	30.6	41.4
					46.2	39.9
<b>Primary Sentencing Guideline</b>						
§2D1.1 ( <i>drug traf.</i> )	21.2	16.7	19.8	26.1	37.7	48.1
§2F1.1 ( <i>fraud</i> )	16.9	9.3	26.3	33.8	42.3	51.2
§2B1.1 ( <i>larceny</i> )	19.1	11.6	37.9	56.6	43.0	57.4
§2K2.1 ( <i>firearms</i> )	42.3	23.7	26.8	44.1	53.0	54.2
§2B3.1 ( <i>robbery</i> )	41.2	33.7	31.4	38.8	57.1	45.2
All Other Guidelines	20.5	12.6	23.6	34.0	34.0	53.7
						55.1

<sup>1</sup> Primary recidivism definition based on offender's re-arrest, including supervised release/ probation violations, re-arrest, or re-conviction.

<sup>2</sup> Number of offenders with a 24 month period at risk of recidivating following either initiation of probation (for offenders receiving probation-only sentences) or release from confinement (for those offenders receiving confinement sentences).

<sup>3</sup> The sentence imposed for the offender's instant offense, presented in months.

SOURCE: U.S. Sentencing Commission, FY1992 Recidivism Sample (U.S. Citizens), 2003, weighted data.

Exhibit 12  
**Primary Definition Recidivism Rates<sup>1</sup> for Instant Offense Characteristics, by Criminal History Category**  
**Type of Sentence, Length of Sentence, and Departure Status**  
 Recidivism Study 2003

<b>CRIMINAL HISTORY CATEGORIES</b>						
<b>Offense Characteristics</b>	Total	Category I	Category II	Category III	Category IV	Category V
	Percent Recidivating					
<b>TOTAL<sup>2</sup></b>						
	24,335	15,429	2,857	2,844	1,359	779
<b>Type of Sentence</b>						
Fine Only	1.2	0.0‡	0.0‡	0.0‡	0.0‡	0.0‡
Probation Only	15.1	12.7	21.8	36.4	42.9	64.7
Probation + Alternatives	16.7	13.3	29.4	37.2	44.1	73.3
Prison + Alternatives	18.3	12.1	26.3	32.5	57.1	50.0
Prison Only	25.6	14.8	23.6	34.0	44.2	50.8
<b>Length of Sentence<sup>3</sup></b>						
0	15.7	12.8	25.2	36.8	44.4	68.8
01 – 05	14.3	7.4	32.7	31.2	66.7	55.6
06 – 11	27.1	17.2	25.0	45.5	42.3	64.0
12 – 23	28.4	16.5	27.2	40.4	51.0	50.7
24 – 59	26.8	14.0	22.9	34.4	44.6	51.3
60 or More	22.7	15.1	19.1	22.3	36.6	46.7
<b>Departure Status</b>						
Within Guideline	23.3	14.6	25.5	37.0	45.8	51.7
Upward Departure	27.8	0.0‡	14.3‡	22.2	44.4	57.1
Substantial Asst.	17.9	11.5	19.0	24.7	40.2	57.7
Other Downward	23.0	16.7	27.3	29.8	39.2	30.5

<sup>1</sup> Primary recidivism definition based on offender's re-arrest, including supervised release/probation violations, re-arrest, or re-conviction.

<sup>2</sup> Number of offenders with a 24 month period at risk of recidivating following either initiation of probation (for offenders receiving probation-only sentences) or release from confinement (for those offenders receiving confinement sentences).

<sup>3</sup> The sentence imposed for the offender's instant offense, presented in months.

‡ Indicates fewer than 10 sample subjects. Findings may not be statistically significant.  
 SOURCE: U.S. Sentencing Commission, FY1992 Recidivism Sample (U.S. Citizens), 2003, weighted data.

Exhibit 13

**Offenders' Recidivating Offense Under the Primary Recidivism Definition,<sup>1</sup>**  
**by Criminal History Category**

Recidivism Study 2003

**CRIMINAL HISTORY CATEGORIES**

	<b>CRIMINAL HISTORY CATEGORIES</b>					
	Total Percent	Category I Percent	Category II Percent	Category III Percent	Category IV Percent	Category V Percent
TOTAL PERCENT	100.0	100.0	100.0	100.0	100.0	100.0
<b>Recidivating Offense Type<sup>2</sup></b>						
Probation Rev.	20.8	24.1	21.8	20.8	17.8	14.7
Supervision Rev.	18.6	14.0	17.4	19.6	25.1	26.7
Fraud	4.8	5.9	5.1	5.1	2.5‡	2.1‡
Drug Possession	5.6	5.2‡	2.6‡	8.8	4.5	4.0
Drug Trafficking	8.8	11.1	9.3	7.4	6.4	5.5
Larceny	7.7	6.9	8.0	5.6	5.7	4.1
DUI	4.9	6.1	6.0	5.0	2.3‡	14.9
Serious Violent Offense <sup>3</sup>	11.7	9.6	13.5	12.2	16.3	9.5
Other	17.1	17.1	16.3	15.5	18.2	20.3
(N=5,377) <sup>4</sup>	(N=2,128) <sup>4</sup>	(N=687) <sup>4</sup>	(N=974) <sup>4</sup>	(N=606) <sup>4</sup>	(N=400) <sup>4</sup>	(N=582) <sup>4</sup>

<sup>1</sup> Primary recidivism definition based on offender's re-arrest, including supervised release/ probation violations, re-arrest, or re-conviction.

<sup>2</sup> Offense types only for offenders' who had a first recidivism event during the 24 month recidivism follow-up period after either initiation of probation (for offenders receiving probation-only sentences) or release from confinement (for those offenders receiving confinement sentences).

<sup>3</sup> "Serious Violent Offense" category includes re-arrests for the following offense types: homicide, kidnapping, robbery, sexual assault, aggravated assault, domestic violence, and weapon offenses.

<sup>4</sup> Number of offenders who recidivated in the given CHC.

‡ Indicates fewer than 10 sample subjects. Findings may not be statistically significant.

SOURCE: U.S. Sentencing Commission, FY1992 Recidivism Sample (U.S. Citizens), 2003, weighted data.

## Appendix A

### Evaluating Predictive Power with the Area Under the Receiver Operating Characteristic Curve

**D**etermining the area under a specific geometric curve is an established technique for measuring the predictive power of a measurement instrument. This technique is well established in diagnostic testing for health disorders when a procedure is used to determine the presence of a disease. If the diagnostic test accurately predicts the presence of the disease, this is a “true positive” result. However, the researcher must also know how often a diagnostic test indicates that a disease is present when in fact the disease is not present. This type of prediction error is called a “false positive” result. The best prediction tool maximizes true positives and minimizes false positives.<sup>33</sup> The technique that analyzes prediction accuracy uses a graph that maps the “true positive” rate against the “false positive” rate. The curve of this graph is called a receiver operating characteristic (ROC) curve. The area under the curve provides a measure of the predictive power of the prediction instrument. The paragraphs below illustrate how this technique is used.

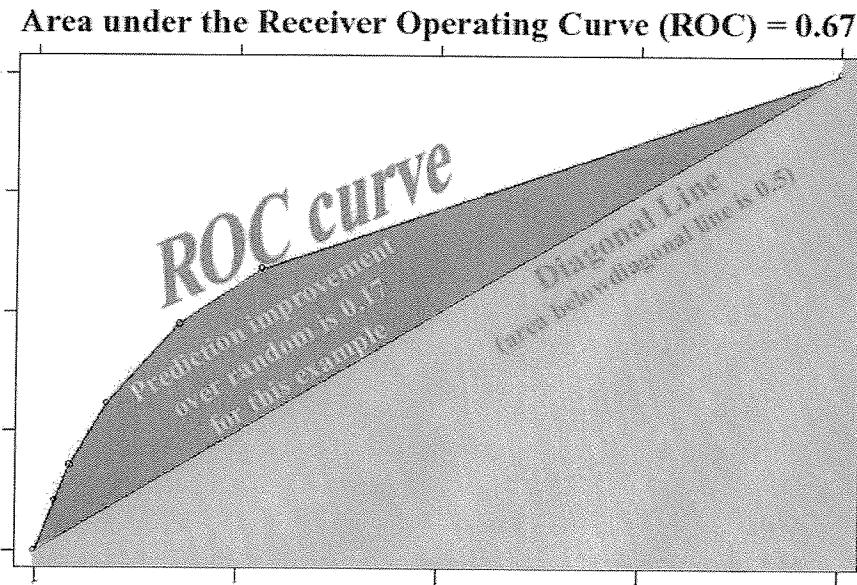
ROC analysis is a straightforward application of this technique to recidivism research. Here the measurement instrument is the offender’s prior criminal history. For this example, assume that the instrument measures criminal history points. The points are used to predict recidivism. The analysis must show how often the measure of criminal history points accurately predicts recidivism, compared to how often the measure of criminal history points predicts recidivism incorrectly.

Graphically, the data is shown in a rectangular box with the area being one unit, as shown in the figure below. A diagonal line is drawn from the lower left to the upper right corners, bisecting the rectangle into two equal parts. The area below the diagonal line measures one half the area of the box (i.e., 0.5 units) and represents “random” prediction, or no predictive power at all. Any observation along the diagonal line is equally likely to be a true positive or a false positive. This line, and the area of the rectangle below it, is the comparison point for the recidivism model.

When the observed true positive and false positive recidivism data are plotted in this rectangular box,<sup>34</sup> they form a line that curves upward from the diagonal line. This curved line is the ROC curve. The higher the ROC line curves above the diagonal line (and toward the top and left side of the rectangle), the greater the area under its curve. The area under the ROC curve represents the predictive power of the criminal history model. Because the ROC curve is higher than the

<sup>33</sup>This is a simplified explanation. For the sake of clarity, additional issues involving “true negatives” and “false negatives” are not considered.

<sup>34</sup>On the graph, the false positive rate is plotted along the x axis and the true positive rate (called the “sensitivity”) is plotted along the y axis. The false positive rate is defined as 1 minus the specificity.



diagonal line, the area under the ROC curve is greater than the area under the diagonal line. Thus, as represented in the figure, the ROC curve improves upon random chance prediction.

The statistic used to measure the predictive power of the criminal history model is the “AUC”: the Area Under the Curve. The greater the AUC, the better the predictive power of the measurement instrument.

The AUC has several desirable qualities as a prediction power gauge. First, and in the context of prior criminal history predicting recidivism, the AUC is interpreted as the probability that a randomly chosen known recidivist will have more prior criminal history than a randomly chosen known non-recidivist. Therefore, the AUC ranges from 0.5 to 1.0.

- With an AUC of 0.5, a randomly chosen known recidivist has a 50 percent chance of having more prior criminal history than a randomly chosen non-recidivist. This would mean that there is no relationship between recidivism and prior criminal history.
- With an AUC of 1.0, 100 percent of the randomly chosen recidivists will have more prior criminal history than the randomly chosen non-recidivists, meaning that prior criminal history predicts recidivism perfectly. With an AUC of 1.0, all recidivists would have more prior criminal history than all non-recidivists.

AUCs between 0.5 and 1.0 indicate a “better than random” predictive accuracy, but a “less

than perfect" predictive accuracy. For the hypothetical example appearing in the figure above, the AUC of 0.67 indicates that 67 out of 100 times, randomly chosen recidivists and non-recidivists are compared, a recidivist would have more prior criminal history than a non-recidivist. This indicates that while the extent of prior criminal history is a strong predictor of recidivism, it is not a perfect predictor. The prediction power of a criminal history measure might be improved by adding or changing its components. However, both legal and policy factors guide the types of characteristics that can be part of a prediction model.<sup>35</sup>

The AUC statistic has three additional desirable properties. It is insensitive to the base rate of recidivism. It can be used across multiple predictive instruments to compare statistically significant prediction power differences.<sup>36</sup> Finally, the AUC can be graphically represented allowing visual comparisons among multiple curves calculated from different prediction instruments.



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<sup>35</sup>The introductory comments of USSG Ch.4, Pt. A states that "while empirical research has shown that other factors are correlated highly with the likelihood of recidivism, e.g., age and drug abuse, for policy reasons they were not included here at this time."

<sup>36</sup>Hanley and McNeil, 1982; Hanley and McNeil, 1983, Delong, Delong, and Clarke-Pearson, 1988. The ability to compare different criminal history models makes AUC an important tool in assessing impacts of changes to the guidelines' Chapter Four provisions.

## Appendix B

### Evaluating Predictive Power with Survival Analysis

**S**urvival analysis, also called hazard rate analysis, is a method that can be used to evaluate the predictive ability of the guidelines' criminal history measure. Survival analysis measures the ability of criminal history to predict how rapidly offenders recidivate during the follow-up period.<sup>37</sup> The concept of crimes committed per unit of time has its roots in the incapacitation literature, where great effort was expended to identify offenders who committed crimes frequently. These repeat offenders were individuals committing multiple crimes in a given period, such as daily, monthly, or yearly. By identifying frequent offenders, they could be targeted for longer prison terms than offenders who commit crimes less frequently. Incapacitation literature argues that the selective targeting of frequent offenders would result in a more efficient use of prison resources as a means of crime reduction.

Survival analysis is used here to examine how well criminal history predicts the number of crimes offenders will commit during a specific follow-up period. The example below illustrates its strengths.

Assume a researcher has recidivism data for 200 offenders who were released from prison all on the same day. Assume that all 200 offenders recidivate during the first two years back in the community.

- The first 100 of the offenders all recidivate on the last day of the two year follow-up, the 730<sup>th</sup> day. Thus, 100 crimes were committed on day 730. The daily rate of crime for this group is 100 crimes divided by 730 days, or 0.1370 offenses per day.
- The second 100 of these offenders all recidivate on the first day of the follow-up period. Thus, 100 crimes were committed on day one. The daily rate of crime for this group is 100 crimes divided by one day, or 100 offenses per day.

These two groups have different speeds of offending. Within 730 days, the first group is expected to commit 100 crimes. During the same 730 day period, however, the second group is expected to commit 73,000 crimes (assuming, of course, that none are apprehended).

Although an extreme example, it illustrates the concern of crime control advocates with respect to their goal of protecting the public. This approach argues that criminal history must have

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<sup>37</sup>Allison, 1995; Hosmer and Lemeshow, 1999; Klein and Moeschberger, 1997.

the predictive power to identify offenders who pose a greater risk to public. Survival analysis allows for this evaluation of the prior criminal history measures.

Survival analysis and the AUC<sup>38</sup> provide different perspectives on recidivism risk. The AUC measures how well prior criminal history predicts whether offenders recidivate or not during a fixed follow-up period. Given the 100 percent rate of recidivism for both groups in the example, the AUC would be identical when using criminal history to predict recidivism separately for each group of offenders. The AUC is not sensitive to the speed at which offenders recidivate and therefore, does not gauge how well criminal history predicts the frequency of re-offending.

In contrast, survival models are sensitive to the speed of recidivism and therefore provide a way to test how well criminal history measures this important aspect of re-offending risk. The survival curves in Exhibit 5 show, from a survival analysis perspective, the rapidity of recidivism for each day of the two year follow-up period, for each of the six CHCs (I through VI). Offenders in CHCs V and VI recidivate most rapidly and therefore if not apprehended, are likely to offend more frequently during the two year follow-up period than are offenders in CHC I.

Survival analysis has another advantage over the AUC when used to evaluate criminal history's ability to predict recidivism. Multiple regression methods for survival analysis have been developed that allow simultaneous evaluation of the independent contribution to predictive power of the various criminal history components.<sup>39</sup> The proportional hazard model estimates presented below test whether each individual CHC contributes uniquely when predicting the rapidity of recidivism. As discussed in the report, CHCs I, II, III, and IV have independent and significant effects on predicting recidivism. However, the impact of CHC V and CHC VI are not statistically different. This finding is, however, somewhat misleading, because offenders sentenced under the career offender guideline (§4B1.1) and the armed career criminal guideline (§4B1.4) can be assigned to criminal history category VI, even if they have fewer than 13 criminal history points, the minimum number of points otherwise needed for an offender to be placed in category VI. Approximately 345 offenders in the weighted recidivism two year follow-up sample had fewer than 13 criminal history points, but were assigned to criminal history category VI for sentencing. When the hazard model using criminal history categories predicting days until recidivism was rerun for criminal history categories assigned based only on criminal history points, the statistical tests show that all categories are significantly different from one another, including categories V and VI. Results indicating that category VI offenders have higher recidivism rates than offenders in category V. In sum, it appears that assigning offenders to criminal history category VI, under the career criminal or armed career criminal guidelines, is for reasons other than their recidivism risk. The survival analyses described here will be explored further in forthcoming papers.

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<sup>38</sup>AUC denotes the Area Under the Curve analysis from the ROC curve, described in Appendix A.

<sup>39</sup>Companion reports in the recidivism project series perform these analyses such as, whether the guideline provision of "recency points" (§4A1.1(e)) adds significantly to predictive power over and above other criminal history components.

**Proportional Hazard Model Estimates for  
Criminal History Category Variables**

*Two Year Primary Recidivism Definition  
Each CHC is analyzed as a binomial variable with Category I as the Comparison Category.*

**Statistical Tests for Differences Between  
Criminal History Category Dummy Variable Coefficients**

Variable	Parameter Estimate	Standard Error	Pr > ChiSq	Hazard Ratio
CAT_II	0.62261	0.04613	<.0001	1.864
CAT_III	1.04420	0.04024	<.0001	2.841
CAT_IV	1.38747	0.04410	<.0001	4.005
CAT_V	1.61343	0.05522	<.0001	5.020
CAT_VI	1.68928	0.04796	<.0001	5.416
Likelihood Ratio	2131.0946		<.0001	

**Hypotheses Tests for Equality between  
Successive Criminal History Category Coefficients**

Label	Wald Chi-Square	DF	Pr > ChiSq
CAT_II = CAT_III	64.0514	1	<.0001
CAT_III = CAT_IV	46.5174	1	<.0001
CAT_IV = CAT_V	12.7208	1	0.0004
CAT_V = CAT_VI	1.3180	1	0.2510

